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AIRCRAFT GUN SYSTEMS EFFECTIVENESS ANALYSIS

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The effectiveness of conceptual helicopter gun systems ranging from 30 millimeters to 105 millimeters is compared for both armored and personnel targets. Projectiles considered are shaped charge and high explosive fragmentation. The scenario considered was a helicopter hover at low altitude with the target from 500 to 4000 meters away. At the longer range, the effectiveness of gun systems is shown to be low even when used with very accurate systems. The relative lethality is such that approximately eight rounds of 30mm are equivalent to one 105mm round. This relative comparison is dependent on

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specific gun system parameters and is shown to be very sensitive to projectile impact zone dimensions for personnel targets. (U) Jones, Harry P.

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The guidance given by Mr. Thomas J. Redling of Rock Island Arsenal is gratefully acknowledged.

INTRODUCTION

An analysis of conceptual gun systems for use on Army helicopters was conducted. The objective of this analysis was to compare the relative effectiveness of gun systems in the 30mm to 105mm range, and to obtain an estimate of the actual lethality of these systems.

This analysis was limited to the following projectiles:

(a) 30 millimeter (similar to Army AMC 30mm),

(b) 75 millimeter,

(c) 105 millimeter (similar to M1 105).

The projectiles considered were shaped charge and high explosive (HE) fragmentation. For the larger gun sizes a closed breech weapon with a recoil cancellation (impulse generator) or a Davis type gun were envisioned. A hit probability (P_h)/kill probability (P_k) model (PKEVAL) was used to simulate the firing of the projectiles on a target by an aircraft.

The scenarios considered were limited to a 50 foot hover altitude at ranges of 500, 1,000, 2,000, and 4,000 meters.

Hypothetical launch angle errors of 2, 5, 10, and 15 milliradians bias and dispersion (one standard deviation) in elevation and azimuth were used. The geometry of the delivery error situations used is presented in Figure 1.

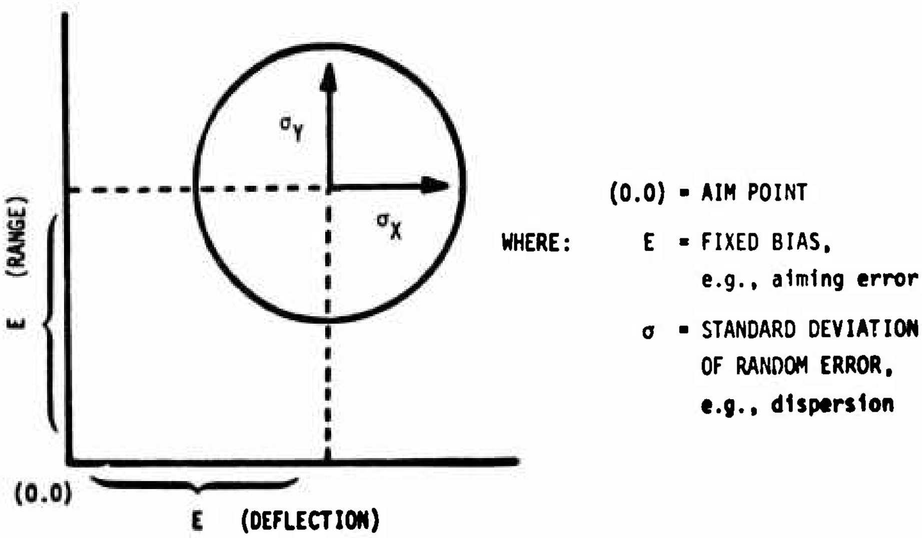

Figure 1 **Geometry of Delivery Error Situations**
(For Figures 2,3, and 4, E is equated to σ; this condition maximizes P_h).

Both armored and personnel targets were considered. Data (P_h and P_k) pertaining to armored target vulnerability was obtained from the Joint Munitions Effectiveness Manual (JMEM)[1]. Three models were used in addition to PKEVAL for personnel target analysis.

It is interesting to note that the 30mm round produces more personnel casualties than the 75mm or 105mm round per pound of ammunition. This weight advantage of the 30mm HE rounds cannot be expected to hold for materiel targets such as trucks.

PKEVAL

This P_h/P_k model was used to simulate the firing of projectiles on a target by an aircraft. The input parameters to this model are:

(a) Weapon aiming and dispersion errors,

(b) Aircraft flight path (2 - dimensional),

(c) Weapon firing rate, burst length, time between bursts,

(d) Projectile ballistic data,

(e) Target vulnerability parameters (for point targets).

Output parameters from this model are:

(a) Probability of killing the target during an engagement,

(b) Projectile terminal velocity and impact angle,

(c) Projectile impact zone on the ground.

The last two sets of output parameters are used for subsequent analysis of area targets. See Appendix A for projectile data.

ARMORED TARGET ANALYSIS

The data for air-to-surface armored target vulnerability was obtained from the JMEM. The kill mechanism considered was that due to a shaped charge projectile. Data for kill categories M, P, or K were used in this analysis. If the target dimensions are small relative to the impact zone (so that the P_h can be considered uniform over the target area), then one can multiply the results of this analysis by relative vulnerable areas to estimate the vulnerability

[1] "Joint Munitions Effectiveness Manual, Air-to-Surface, Target Vulnerability", SECRET, (USAF) TH 61A1-1-1-1, (ARMY) FM 101-50-1, (USMC) FMFM 5-2, (NAVY) NAVAIR 00-130-AS-1, Fig 3C-45, pg 3C-26

of other armored targets. The target was represented by an effective vulnerable area that is a function of projectile diameter and impact angle. Data is also available for presentation of P_k given a hit, but this method requires a calculation of actual target presented area. The agreement of these two methods was satisfactory for the trial cases.

Figure 2 shows the number of rounds required to achieve a 50 percent probability of killing the armored target. Since the scale for the number of rounds is logarithmic, the number of rounds (fig 2&3) is printed by the points for convenience in viewing. The ratios of the number of rounds, of the different projectiles, required to achieve a 50 percent P_k at all ranges are fairly constant. For example, the number of 30mm rounds to equal one 105mm round is approximately eight. The number of 30mm rounds to equal one 75mm round is approximately five. The number of rounds required increases exponentially with increasing range to target.

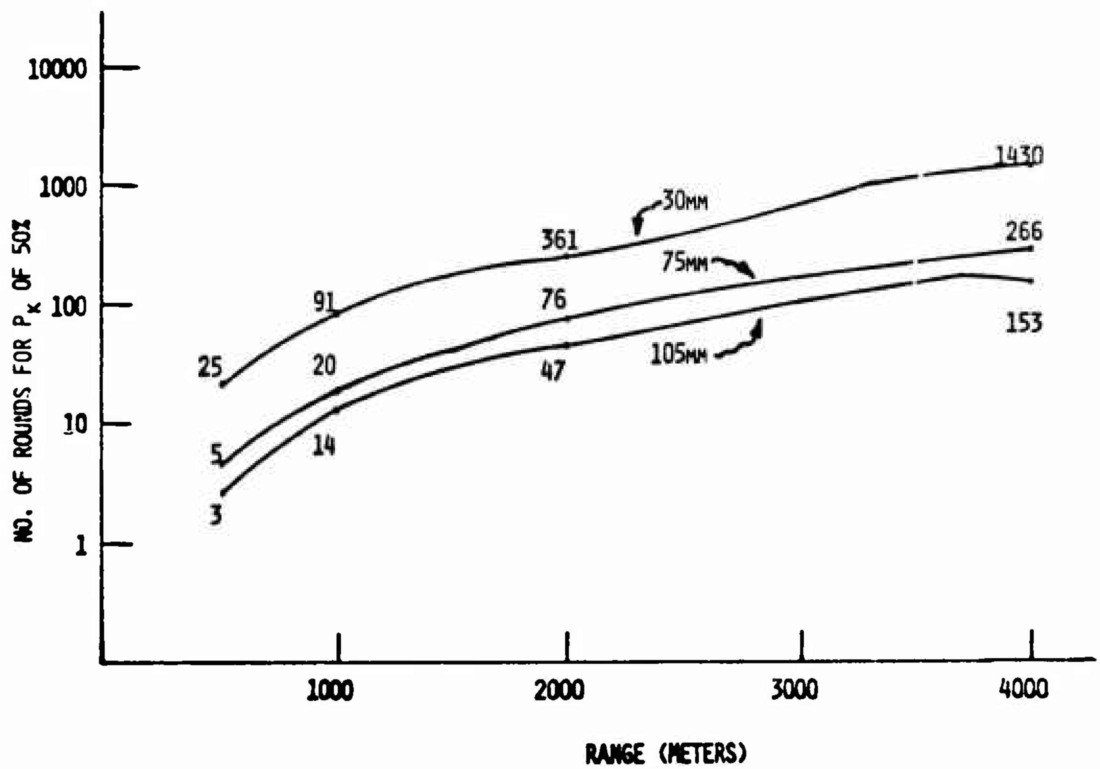

Figure 2. Number of rounds to defeat armored target with 2 mR aiming and dispersion error in range and deflection

Figure 3 shows the effect of changing launch error from 2 to 5 milliradians bias and dispersion in each axis. The number of rounds required in each case is increased by a factor of approximately six.

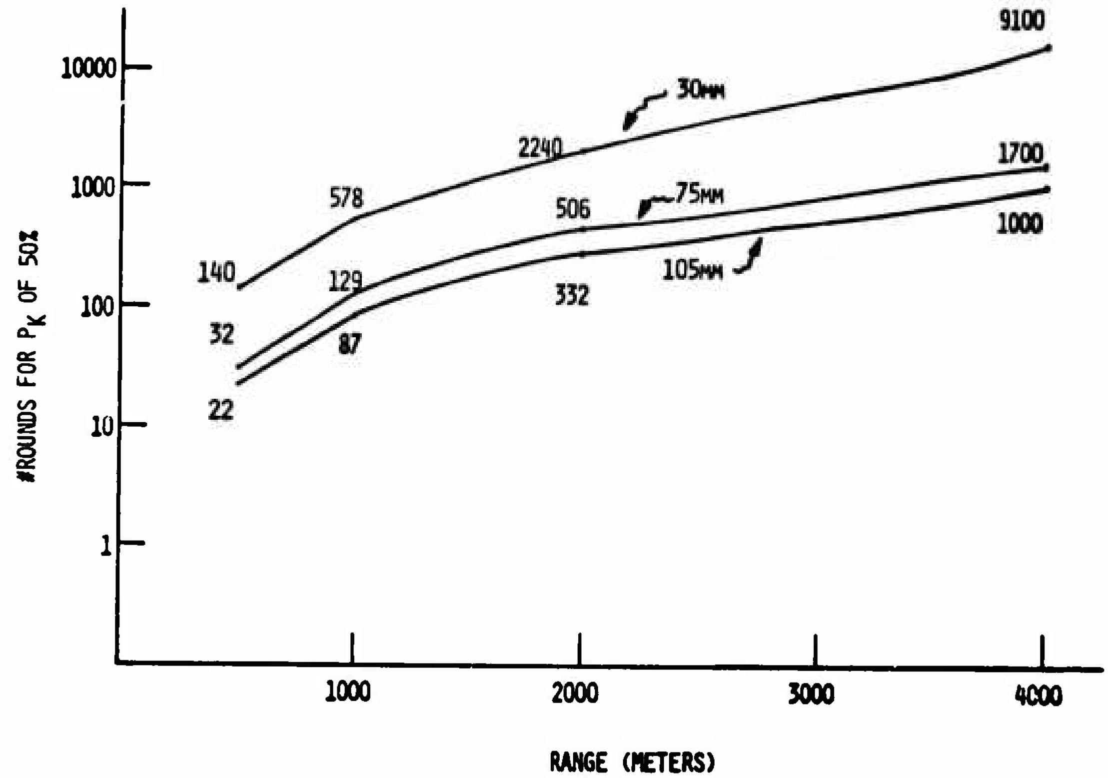

Figure 3. Number of rounds to defeat armored target with 5 mR aiming and dispersion error in range and deflection.

PERSONNEL TARGET ANALYSIS

Three models were used for the personnel target analysis in addition to the PKEVAL Model. These models are:

(a) A Computational Method for Predicting from Design Parameters the Effective Lethal Area of Naturally Fragmenting Weapons[2]. This model furnishes projectile fragmentation data (size, number, velocity, angular zone) given the basic HE projectile dimensions, material, and filler.

[2] "A Computational Method for Predicting from Design Parameters the Effective Lethal Area of Naturally Fragmenting Weapons," Unclassified, Research & Development Department, Naval Ordnance Station, Indian Head, MD, AD 857 530, Nos - IHTR-295.

(b) Computer Program for General Full Spray Personnel Mean Area of Effectiveness Computations[3]. This model gives a matrix of P_k or incapacitation on the ground plane. The required inputs are fragmentation data, target vulnerability data, projectile impact angle, and projectile terminal velocity.

(c) General Purpose Matrix Program[4]. This program uses impact zone and kill matrix data from other models to summarize the effect of firing several rounds.

The personnel casualty criterion data used in this analysis was obtained from the JMEM for air-to-surface target vulnerability. Data[1] contained in the third row of the clothed soldier column (a, b, n) was used.

Figure 4 shows the number of casualties inflicted per 10,000 personnel in a 300 by 300 foot target area when using high explosive ammunition at various ranges. The gun launch errors for this case are 5 milliradians of bias and dispersion in both range and deflection. Note that the 105mm air burst produces approximately three times as many casualties as the ground burst. The curves are fairly flat over ranges of 1000 meters to 4000 meters, and actually curve upward at the longer ranges. This is due to the fact that a better impact zone distribution is obtained at longer ranges. With this 5 milliradian bias and dispersion system, the number of rounds required to achieve a 50 percent casualty level at 3000 meters range for personnel in a 300 by 300 foot target area are:

105mm Air Burst	110 Rounds
105mm Ground Burst	350 Rounds
30mm Ground Burst	9900 Rounds

[3] "JMEM Computer Program for General Full Spray Personnel Mean Area of Effectiveness Computations, Volume 1, Users Manual, Confidential," 25 May 71 61JTCG/ME-70-6-1, AMXSY-S, Aberdeen Proving Ground, MD.

[4] Einbinder, S.K. "General Purpose Matrix Program", TR 4600, AD 917313, Picatinny Arsenal, Dover, NJ.

[1] Ibid; Figure 2A-19, Page 2A-13, "Parameters for P_{hk} Curves - 100% Incapacitation" Row 3 - Tumbling Flechettes, Clothes Soldier Columns a, b, n.

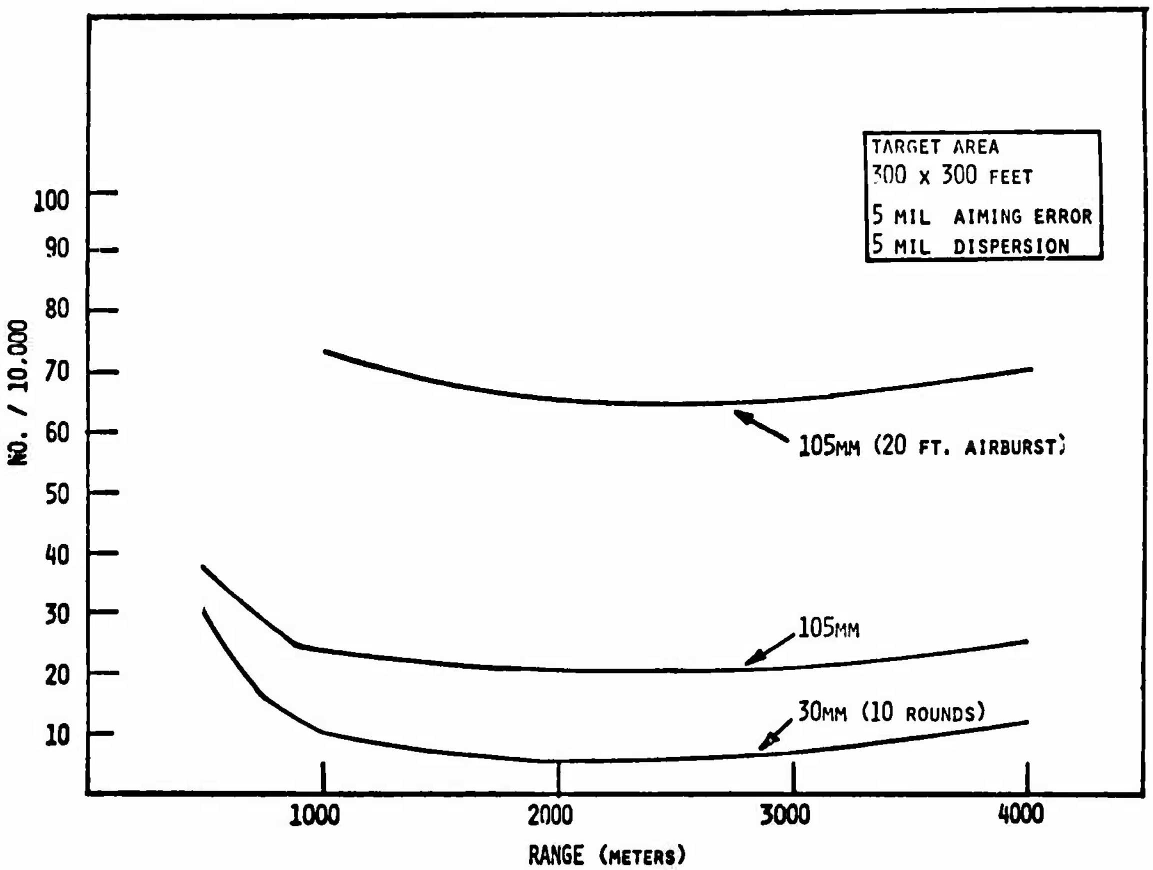

Figure 4. Fractional personnel casualty level.

See Appendix B for graphs of fractional casualty level versus target size for various aiming errors.

Figure 5 shows the number of 30mm rounds that are required to equal one 105mm round's casualty level. This ratio was obtained by averaging over a wide range of aiming errors and target areas. Unlike the armored target case, where the ratio was approximately constant at 8 to 1, it varies widely here with range. The reason for this variation is that the 30mm round has a flatter trajectory than the 105mm round at medium ranges, hence, a more elongated dispersion pattern results. At short ranges both rounds have fairly flat trajectories so the lethality ratio approaches an approximate 9 to 1 ratio. As the range is extended to 3000 meters and beyond, the 30mm is slowed down relatively more than the 105mm, and its impact angle approaches that of the 105mm round.

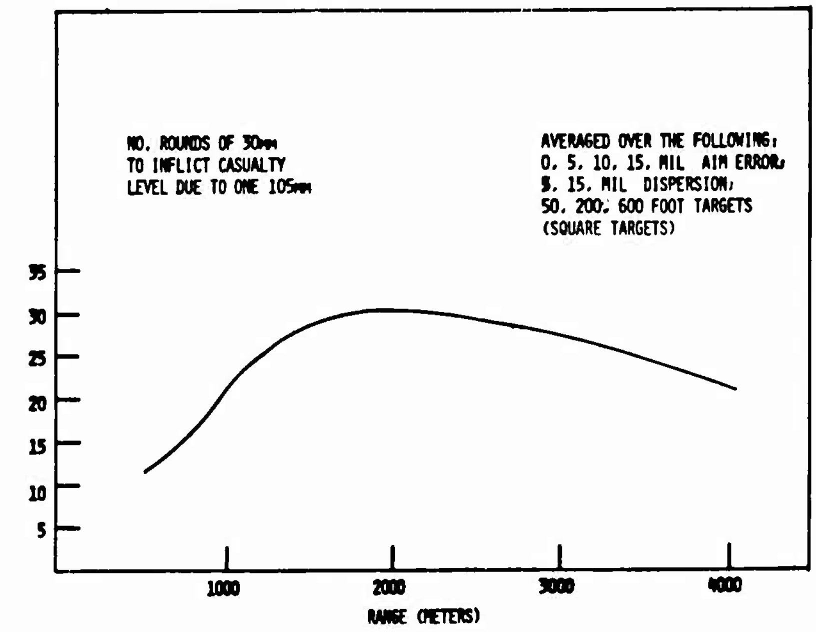

Figure 5. Comparing the 30mm and 105mm round lethality ratios.

Figure 6 shows the ratios of the impact zone sizes for various launch altitudes and ranges. At higher altitudes the variation in impact zone size with range decreases.

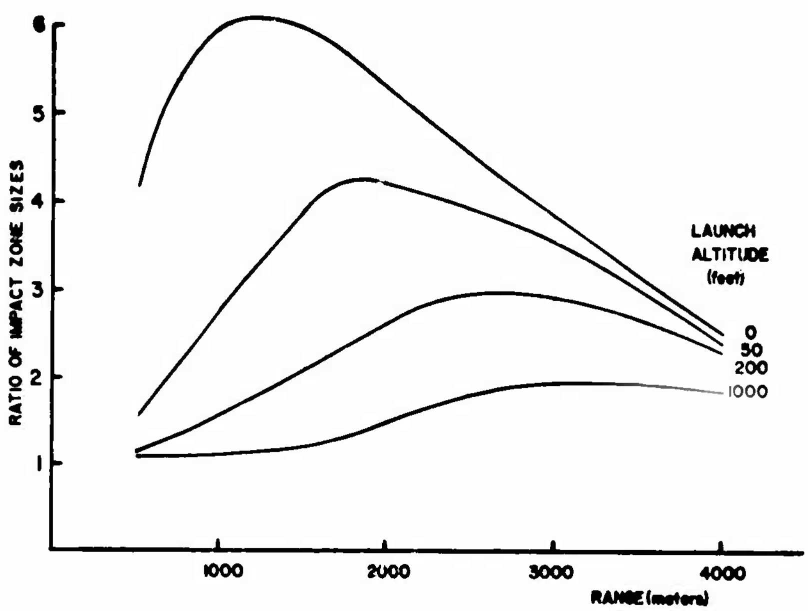

Figure 6. Comparison of a 30mm round impact zone size to that of a 105mm round impact zone size.

CONCLUSIONS

This analysis was limited to three projectiles and was not a complete relative effectiveness analysis. Several additional factors should be considered to obtain the optimum caliber for a helicopter gun system. These factors are:

1. Specific scenarios and relative frequencies of each,

2. The total number of rounds carried per mission,

3. The cost of flying a mission,

4. The cost of projectiles of various sizes,

5. Round-to-round dispersion and bias aiming errors as functions of caliber,

6. Aircraft vulnerability to antiaircraft fire as a function of aircraft altitude, range, and exposure time,

7. Firing rate as a function of caliber,

8. Production and maintenance costs of the weapon system amortized per round fired.

Several different effectiveness criteria may be considered in applying the lethality data calculated for this report. The lethality of all the gun weapon systems considered is generally low. Even the hypothetical 2 milliradian bias and dispersion system is not very lethal at longer ranges, when fired at point targets. The lethality of gun systems used against personnel targets is rather insensitive to range when fired from low altitudes. Several trade-offs are indicated among aircraft altitude, projectile muzzle velocity, and fire control accuracy. Firing high velocity projectiles from low altitudes causes a detrimental increase in the length of the impact zone on the ground. Firing from higher altitudes may decrease the aircrafts' probability of survival if air defense units are present. Firing lower velocity projectiles will improve the impact zone; however, it will have a detrimental effect on fire control accuracy.

The importance of fire control accuracy depends on the target size. For point targets accuracy is very important, however, for very large area targets accuracy may be relatively unimportant.

Per pound of ammunition, the 30mm round produces more casualties than the 75mm or 105mm. This is due to the 30mm projectile breaking into more optimum fragment sizes (smaller) for personnel casualties. The weight advantage of 30mm HE rounds can not be expected to hold for other materiel targets such as trucks.

APPENDIX A

30mm and 105mm

PROJECTILE DATA

PROJECTILE	DISPERSION (mil s)	RANGE (meters)	DISPERSION (METERS) UP	DOWN	DEFL.	IMPACT ANGLE (degrees)	TERMINAL VELOCITY (meters/sec.)
30mm	10	4000	340	405	40	6.2	306
	10	2000	735	725	20	1.5	604
	10	1000	625	345	10	1.2	826
	10	500	210	115	5	1.8	960
	5	4000	180	195	20	6.2	306
	5	2000	380	385	10	1.5	604
	5	1000	280	205	5	1.2	826
	5	500	90	65	2.5	1.8	960
105mm	10	4000	150	150	40	14.3	263
	10	2000	185	185	20	6.1	298
	10	1000	175	160	10	3.4	325
	10	500	110	85	5	2.9	343
	5	4000	75	70	20	14.3	263
	5	2000	95	90	10	6.1	298
	5	1000	85	80	5	3.4	325
	5	500	55	40	2.5	2.9	343

30mm Muzzle Velocity = 366 meters/second

30mm Projectile Mass = 0.326 kilograms

105mm Muzzle Velocity = 1097 meters/second

105mm Projectile Mass = 13 kilograms

APPENDIX B

FRACTIONAL CASUALTY LEVEL

Vs

TARGET SIZE

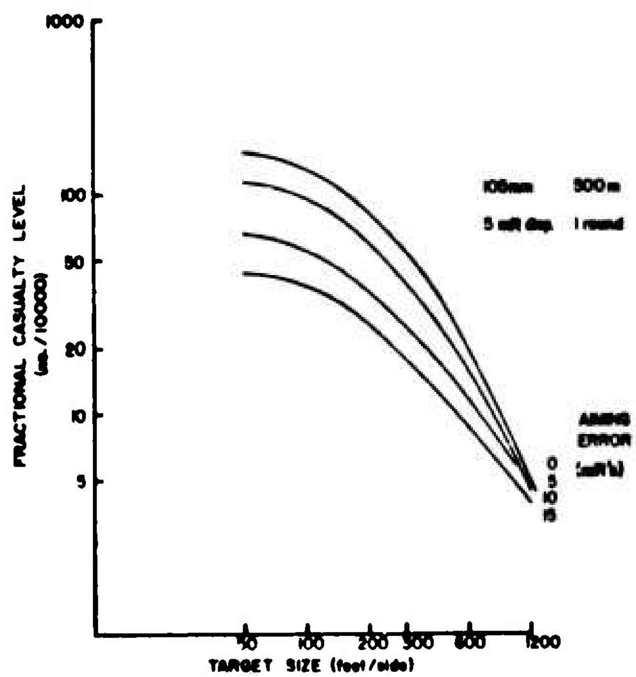

Figure B-1. Fractional casualty level vs target size for one round of 105mm at 500m with a 5 mR dispersion.

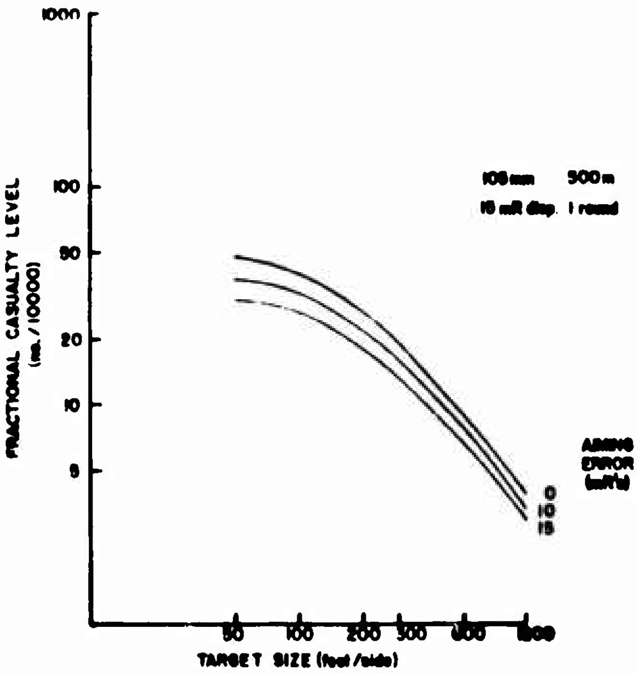

Figure B-2. Fractional casualty level vs target size for one round of 105mm at 500m with a 15 mR dispersion

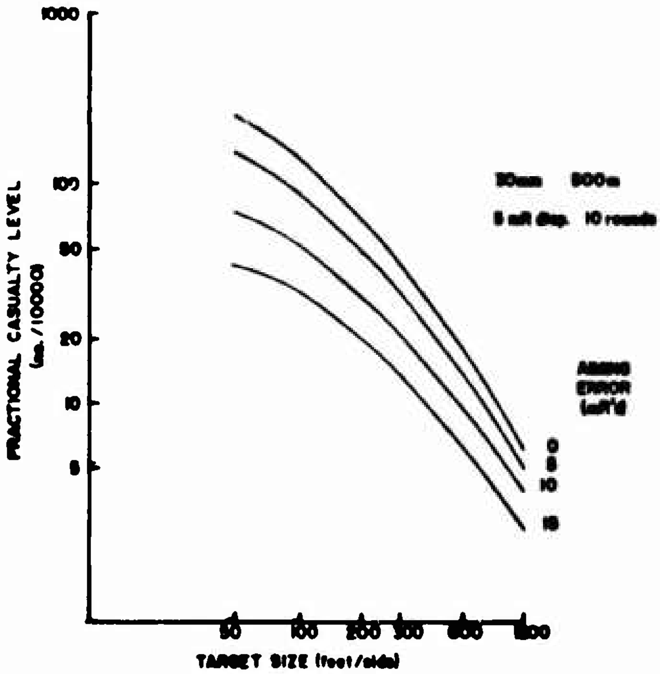

Figure B-3. Fractional casualty level vs target size for ten rounds of 30mm at 500m with a 5 mR dispersion.

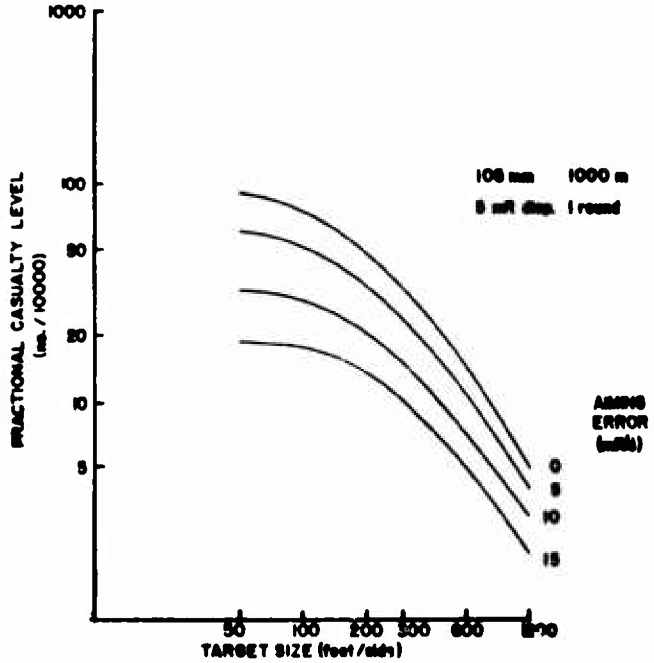

Figure B-4. Fractional casualty level vs target size for one round of 105mm at 1000m with a 5 mR dispersion.

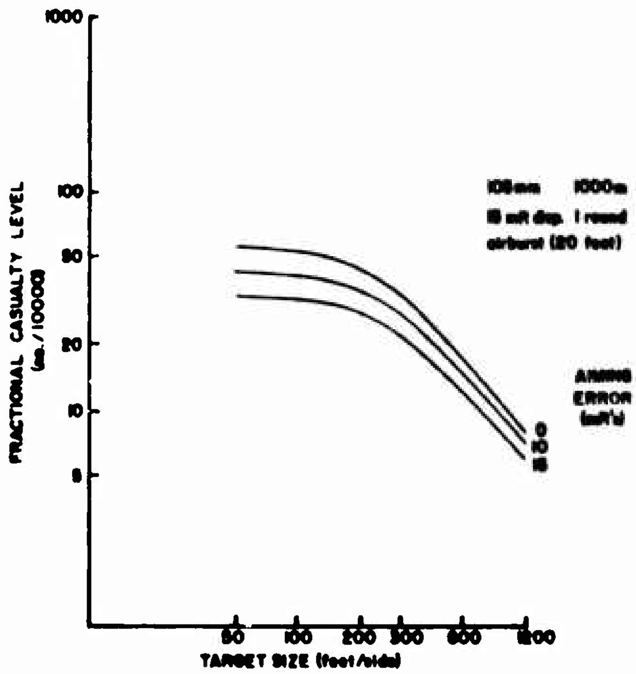

Figure B-5. Fractional casualty level vs target size for one airburst (20ft) round of 105mm at 1000m with a 15 mR dispersion.

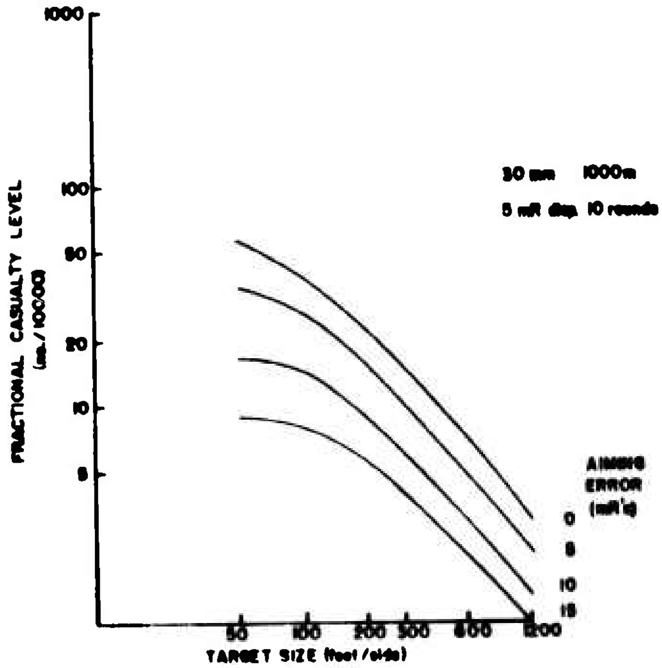

Figure B-6. Fractional casualty level vs target size for ten rounds of 30mm at 1000m with a 5 mR dispersion.

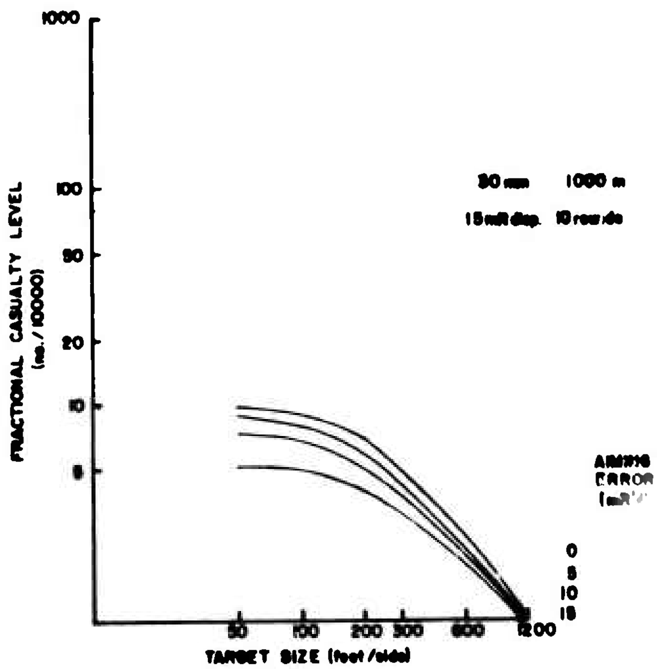

Figure B-7. Fractional casualty level vs target size for ten rounds of 30mm at 1000m with a 15 mR dispersion.

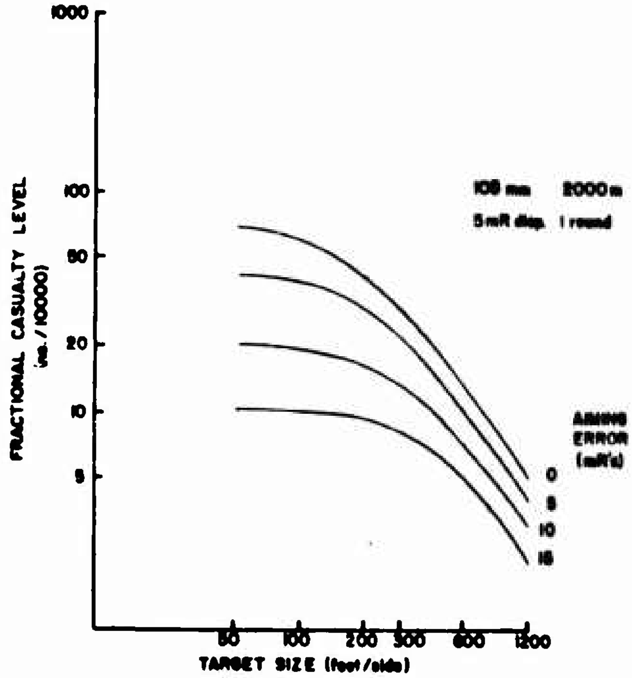

Figure B-8. Fractional casualty level vs target size for one round of 105mm at 2000m with a 5 mR dispersion.

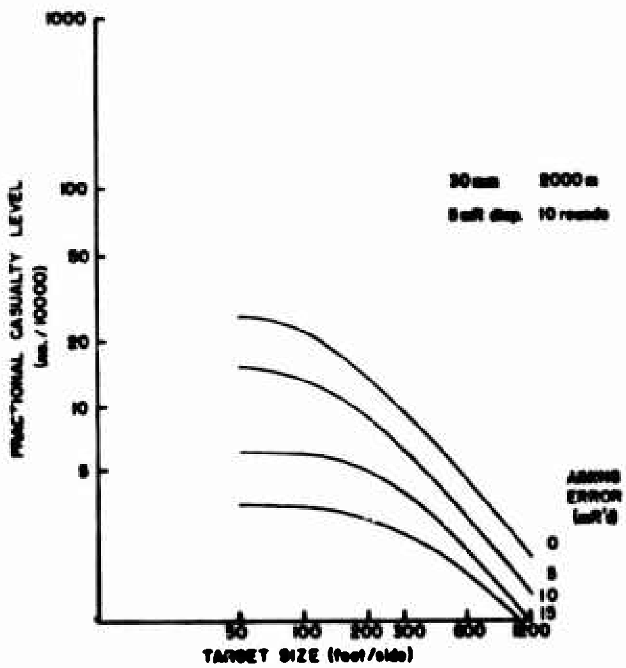

Figure B-9. Fractional casualty level vs target size for ten rounds of 30mm at 2000m with a 5 mR dispersion.

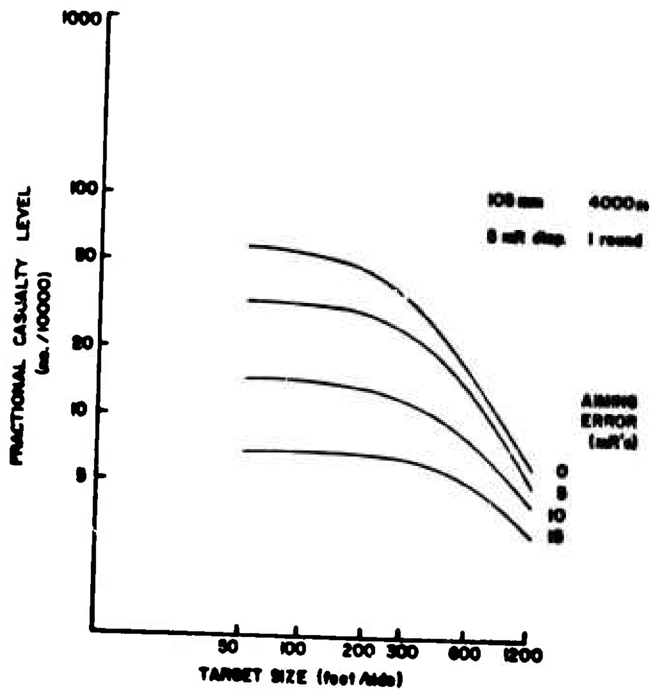

Figure B-10. Fractional casualty level vs target size for one round of 105mm at 4000m with a 5 mR dispersion.

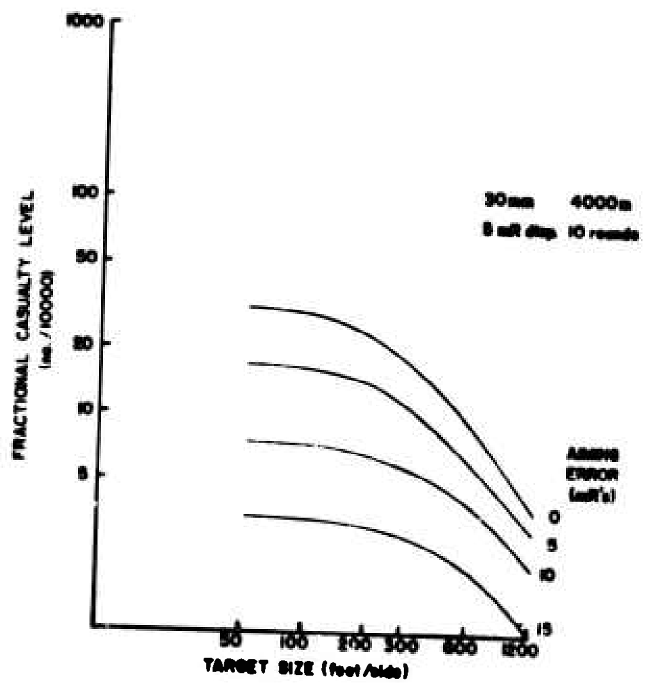

Figure B-11. Fractional casualty level vs target size for ten rounds of 30mm at 4000m with a 5 mR dispersion.